PTO 07-4357

1995-08-30
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EP 669,116

FEMORAL COMPONENT FOR A HIP JOINT ENDOPROSTHESIS
[Oberschenkelteil für eine Hüftgelenk-Endoprothese]

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UNITED STATES PATENT AND TRADEMARK OFFICE
WASHINGTON, D.C. MAY 2007
TRANSLATED BY: MCELROY TRANSLATION COMPANY

PUBLICATION COUNTRY	(10):	EP
DOCUMENT NUMBER	(11):	0 669 116
DOCUMENT KIND	(12):	A1
PUBLICATION DATE	(43):	19950830 Patent Bulletin 95/35
APPLICATION NUMBER	(21):	95250020.5
APPLICATION DATE	(22):	19950126
INTERNATIONAL CLASSIFICATION[6]	(51):	A 61 F 2/36, A 61 F 2/30
PRIORITY COUNTRY	(33):	DE
PRIORITY NUMBER	(31):	9401429 U
PRIORITY DATE	(32):	19940126
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DESIGNATED CONTRACTING STATES	(84):	AT BE CH DE DK ES FR GB GR IE IT LI LU MC NL PT SE
TITLE	(54):	FEMORAL COMPONENT FOR A HIP JOINT ENDOPROSTHESIS
FOREIGN TITLE	[54A]:	Oberschenkelteil für eine Hüftgelenk-Endoprothese

The subject matter of the present invention relates to a hip joint endoprosthesis of the type disclosed in the preamble portion of Claim 1.

In designing the stem parts of hip joint prostheses, it is of the highest importance, in particular when using cementless anchorage, to achieve an intimate connection between the external surface of the stem and the neighboring bone tissue in those areas that are especially affected by the introduction of forces. This especially requires that the elasticity of the bone tissue, on the one hand, and its strength, on the other hand, be taken into consideration. The resultant strains should neither fall below first specified values nor exceed second specified values. Misalignments lead to micromovements and degradation of the bone tissue, which in turn leads to a further loosening of the prosthesis.

DE-PS 32 16 539 discloses this type of femoral component of a hip joint endoprosthesis with a head portion and a stem intended for cementless anchorage. In the area near the head, the stem has a stem core and an external surface dimensioned so as to be in contact with the cortical substance of the bone, and on the oppositely located surfaces, it has a plurality of ribs extending in the longitudinal direction, with free space for holding bone tissue being enclosed between the neighboring ribs. The height of the ribs, which have fixed widths and are spaced at fixed intervals, increases toward the end of the cone. Furthermore, the marked increase in the depth of the ribs does not make it possible to design a symmetrical prosthesis that is equally suitable for use on the left and on the right side since, because of the physiological structures and the bone space available, the region of added growth is limited by extensions in the dorsal direction.

The prior-art prosthesis has the disadvantage that, due to the existing rib structure, a unilateral, substantially radially directed compaction of the spongiosa takes place when the prosthetic stem is inserted into the prepared upper thigh bone, which leads to an unpredictable increase in the strain--and thus, in particular, also to local load peaks--in the bone material. During the insertion, the shape of the

ribs generates a radial wedge effect which, on improper handling, can even cause the femur to be split lengthwise. Even when normal mechanical loads are exerted, the effect mentioned is further amplified by the settling of the prosthesis over time and may also lead to a loosening of the prosthetic stem with all of the complications associated therewith.

Using the drawbacks of the prior art as the starting point, the problem to be solved by the present invention is to make available a femoral component of the type mentioned in the introduction, which makes it possible to "set" the stem end while at the same time increasing the frictional connection between the prosthesis and the surrounding bone tissue without an overload due to the wedge effect.

This problem is solved by the characterizing features of Claim 1.

The invention is also based on the insight that in order to ensure the long-lasting cementless anchorage of a prosthetic stem, the spongiosa of the upper thigh bone holding the stem must be compacted in several directions--as gradually and uniformly as possible--as a prophylactic measure to prevent an unfavorable strain distribution when the stem is inserted and when normal mechanical loads are exerted on the implanted prosthesis.

Since the femur tapers from proximal to distal, it is possible to achieve the increase in the size of the surface required for ingrowth of the bone material by providing a profile on the lateral surfaces of the prosthetic component and to control the manner of the proximal spongiosa compaction during the insertion of the prosthetic stem into the bone by a profile with dimensions that change from proximal to distal.

The measures according to the present invention make it possible to adapt the external contour of the prosthesis without substantial overdimension to an insertion area that is to be removed inside the femur, with the prosthesis being "set" without a substantial radial wedge effect since said prosthesis is better able to fit into the prepared shape. Therefore, "wedging" takes place mainly in the tangential direction,

with this wedge effect not causing strain that would widen the bone tube but instead leading to a bone compaction that takes place between the adjacent ribs so that the resultant strain is not absorbed by the surrounding bone but directly by the adjacent ribs. The compaction therefore takes place in areas that are located mainly in the vicinity of the enclosing surface contour of the prosthesis. Thus, the "compaction" occurs by means of an increasing clamping effect acting in the tangential direction on areas which, during the insertion or setting of the stem, are passed one after the other by identical surface areas of the rib structure. As a reference for the compaction of the cross section of the ribs in comparison with the clear surface area remaining between the ribs, it is also possible to use the radial distances of the relevant areas from the central axis of the parts of the prosthesis that are jointly moved during the insertion and subsequently form a reference plane for the "tangential wedge effect"--in contrast to the known "radial wedge effect."

A special advantage is the fact that the measures according to the present invention make it possible to create a symmetrical prosthesis for use on both sides which, in its fit, approaches those prosthetic stems that previously required a special asymmetrical shape, with the resultant higher production costs and costs entailed as a result of needing an adequate supply at disposal.

According to a preferred embodiment of the present invention, the femoral component of a hip joint endoprosthesis has a rib-like profile along the proximal wide sides of the stem, with the individual ribs substantially extending in a straight line in the direction of insertion. To ensure the desired compaction of the spongiosa--in particular the proximal spongiosa remaining inside the bone after appropriate preparation for the implantation--in the most uniform manner possible both in the radial and also in a substantially vertical direction thereto, at least the width of the cross-sectional profile of the individual ribs is continuously decreased from proximal to distal. This has the favorable effect that the effective cross-sectional area of the recesses between the ribs gradually decreases from distal to proximal.

According to a useful further development of the invention, it is especially useful from the standpoint of production if the dimensions of the femoral component--which component can be made by forging--determining the cross-sectional profile of the ribs change in a substantially conical manner. The change in the dimensions is achieved in that the cross-sectional area of the recesses between the individual ribs of the profile increases toward distal, while the cross-sectional area of the ribs decreases toward distal.

A useful profile in the context of the solution disclosed by this invention is obtained by disposing ribs with a substantially triangular or rectangular cross-sectional area or a cross-sectional area formed by arched elements along the proximal wide sides of the prosthetic stem. The decrease in the cross-sectional profile area of the ribs (and the increase of the cross-sectional area of the recesses between the ribs) to distal--which is required for the desired compaction of the spongiosa--is implemented by an appropriate variation of the height and/or width or the radius of the line curve that delimits the relevant cross-sectional area or by a variation of the angle between two line curves that delimit the cross-sectional area.

According to another useful embodiment of the present invention, an axial through-bore extending from proximal to distal is provided. In this embodiment, the stem of the prosthesis also has a V-shaped notch in the proximal region along the stem's proximal narrow side and in the distal region along the stem's distal narrow side. The notches extend up to the longitudinal bore of the stem.

Useful further developments of the invention are disclosed in the dependent claims and are explained in greater detail based on the figures and in the description of the preferred embodiment of the invention. As can be seen:

Figure 1 is a schematic diagram of a longitudinal section through a preferred embodiment of the invention,

Figure 2 is the schematic diagram of the view of a section along line C-C shown in Figure 1,

Figure 3 is the top view of the embodiment of the invention shown in Figure 1,

Figure 4 is the diagram of the view of a section along the line B-B shown in Figure 2,

Figure 5 is the diagram of a partial view of the section along line D-D shown in Figure 1,

Figure 5a is the diagram of a partial view of the section along line E-E shown in Figure 1, and

Figures 6, 6a, 6b, 7, 7a, 8, 8a, 8b, 9, 9a and 9b are diagrams of a partial view of the section along line D-D and of a partial view of the section along line E-E shown in Figure 1 as well as a perspective diagram of a profiled stem section for various useful further developments of the preferred embodiment of the invention shown in Figure 1.

The stem portion 1 of a hip joint endoprosthesis is shown in Figures 1, 2 and 3 as a lateral section (Figure 1 as a view of the section along A-A shown in Figure 2, Figure 2 as a view of the longitudinal section along line C-C shown in Figure 1) and as a view from the top. The anatomically optimized geometry of stem 2 of the femoral component 1, which is marked by oval stem cross sections in the proximal region, ensures an optimum introduction of forces into the upper thighbone under the greatest possible number of conditions of load application. Due to the stem end that is conically tapering to distal, the femoral component 1 has a sufficient elasticity, which is mainly implemented by the V-shaped notches 6.1 and 6.2. Notch 6.1 is usefully disposed proximally along the proximal narrow side and distally along the distal narrow side of the stem 2. The required rigidity of the prosthetic stem 2 is ensured by a bore 5 that extends from proximal to distal through the stem.

Both on the anterior and on the posterior surfaces of the stem 2, which expands proximally in a blade-like manner, a profile is disposed, which profile comprises ribs 3 and recesses 4 disposed between said ribs.

This rib structure is designed so that the distance between the individual ribs 3 decreases in the proximal direction and the height of the ribs is at the same time reduced in the distal direction. The decrease of the distance and the reduction of the height are preferably implemented in a conical manner since this provides advantages from the standpoint of the production. The rib structure described above ensures that in the course of the settling taking place after the prosthesis has been implanted, a so-called proximal press-fit connection with metaphyseal anchorage of the prosthetic stem 2 is obtained. The shape-giving rasping as part of the preparation of the medullary space of the femur for proper implantation of the prosthesis is carried out with underdimension in the region of the future position of the rib structure of the stem. This has the positive effect of ensuring a primary clamping action, with the simultaneous compaction of the spongiosa structure. Because of the ribs 3, which conically taper distally both in width and in height, the compaction of the spongiosa takes place not only in the radial direction but at the same time also in the direction substantially vertical thereto. This uniformness of compaction ensures in a favorable manner that the strength is increased, without entailing an additional mechanical load exertion on the cortical substance.

Figure 4 shows the view of a section along line B-B shown in Figure 2. Because of the V-shaped notch 6.2, which extends to the distal end of the stem 2, stem 2 has a special surface moment of inertia which ensures sufficient elasticity and at the same time a "gentle" transmission of forces into the femur.

Figures 5 and 5a show a preferred embodiment of the profile in the proximal region of the stem as a view of a partial section along line D-D and E-E, respectively, according to Figure 1. Both the ribs 3 of the profile of the wall section 7 of the stem and the recesses 4 between the ribs 3 are delimited by

circular arches (Figure 5). To ensure the desired compaction of the spongiosa in the upper thighbone, the cross-sectional area of the recesses 4' is increased in the distal direction (Figure 5a). The cross-sectional area of the ribs 3' is correspondingly reduced. The basic shape of the recesses and the ribs is maintained. Per unit of length, the radius of the ribs is reduced more gradually in proportion to the increase in the radius of the recesses.

Figures 6, 6a, 6b, 7, 7a, 8, 8a, 8b, 9, 9a and 9b show various useful embodiments of the profile of the proximal wide sides of the femoral component of a hip joint endoprosthesis as a view of a partial section through the wall 8, 9, 10, 11 in the proximal region of stem 2 along lines D-D and E-E, respectively. All profiles have in common that the cross-sectional area of the recesses 4.1, 4.2, 4.3, 4.4 and 4.1', 4.2', 4.3', 4.4' increases gradually, preferably conically, from proximal to distal. At the same time, the height of the profiling ribs 3.1, 3.2, 3.3, 3.4 and 3.1', 3.2', 3.3', 3.4' is reduced continuously. The wedge effect resulting therefrom advantageously leads to a compaction of the spongiosa not only in the radial direction but also in the direction perpendicular thereto and securely seats the hip joint endoprosthesis in the upper thighbone.

The cross-sectional area of the profiling ribs and recesses preferably has a rectangular (positions 3.1, 4.1 and 3.1', 4.1' in Figures 6, 6a) or a substantially triangular form (positions 3.3, 4.3 and 3.3', 4.3' in Figures 8, 8a). The desired change in the cross-sectional areas can be ensured in a simple manner by varying the height/lateral surface ratio of a rectangle or by changing the vertical angle and the height of a triangle. Relevant profile sections are shown in Figures 6b and 8b in a perspective view.

For the cross-sectional areas of the recesses (positions 4.2, 4.2' in Figures 7, 7a) and the profiling ribs (positions 3.4, 3.4' in Figures 9, 9a) substantially delimited by arched sections, the relevant change of the radii takes place from proximal to distal. Figure 9a shows a perspective view of a stem section with arch-shaped ribs.

The implementation of the invention is not limited to the preferred practical example described above. Instead, many variations which use the solution disclosed are conceivable, even if the resultant embodiments are different.

Claims

1. A stem prosthesis, in particular a hip joint endoprosthesis, for cementless implantation, with a stem tapering distally which has, in the proximal region on the anterior and posterior external surfaces, a riblike profile which has recesses in the form of longitudinal grooves that extend in the direction of insertion, characterized in that the ratio between the material cross section of the ribs and the clear cross section remaining between the ribs increases in the proximal direction, thus ensuring that the clamping effect of the ribs in the surrounding bone space during the insertion of the prosthesis increases in the distal direction but decreases in the distal direction when the prosthesis is removed.

2. The stem prosthesis as in Claim 1, characterized in that this ratio applies to regions of the ribs and the clear cross section which have the same radial distances from the exterior enveloping contour of the prosthesis and the same radial distances from the center.

3. The stem prosthesis as in either one of the preceding claims, characterized in that the cross section of the recesses forming the clear regions is reduced proximally by decreasing the width of the longitudinal grooves, by decreasing the vertical angle in cases of a triangular or multiangular structure, and by decreasing the radius in cases of a concave structure and by increasing the radius in cases of a convex structure.

4. The stem prosthesis as in any one of the preceding claims, characterized in that the cross section of the recesses decreases substantially continuously.

5. The stem prosthesis as in any one of the preceding claims, characterized in that the clear cross section decreases while substantially maintaining the chosen profile shape of the longitudinal ribs (3, 3.1, 3.2, 3.3, 3.4).

6. The stem prosthesis as in any one of the preceding claims, characterized in that the profiles on the anterior side and on the posterior side of the proximal shaft are identical, in particular mirror-symmetrical.

7. The stem prosthesis as in any one of Claims 1-5, characterized in that the cross-sectional profile of the longitudinal ribs (3.1) has a substantially rectangular shape.

8. The stem prosthesis as in Claim 7, characterized in that the area of the cross-sectional profile is reduced distally by decreasing the width of the rectangle or the width and height of the rectangle.

9. The stem prosthesis as in any one of the preceding claims, characterized in that the cross-sectional profile of the longitudinal ribs (3) is determined by concave and convex arched sections which are arranged in alternating sequence.

10. The stem prosthesis as in any one of the preceding claims, characterized in that the stem has a longitudinal bore.

11. The stem prosthesis as in any one of the preceding claims, characterized in that the stem in the proximal region along the lateral narrow side and in the distal region on the medial narrow side has a notch, especially a V-shaped notch.

12. The stem prosthesis as in Claim 11, characterized in that the notches extend to the longitudinal bore of the shaft.

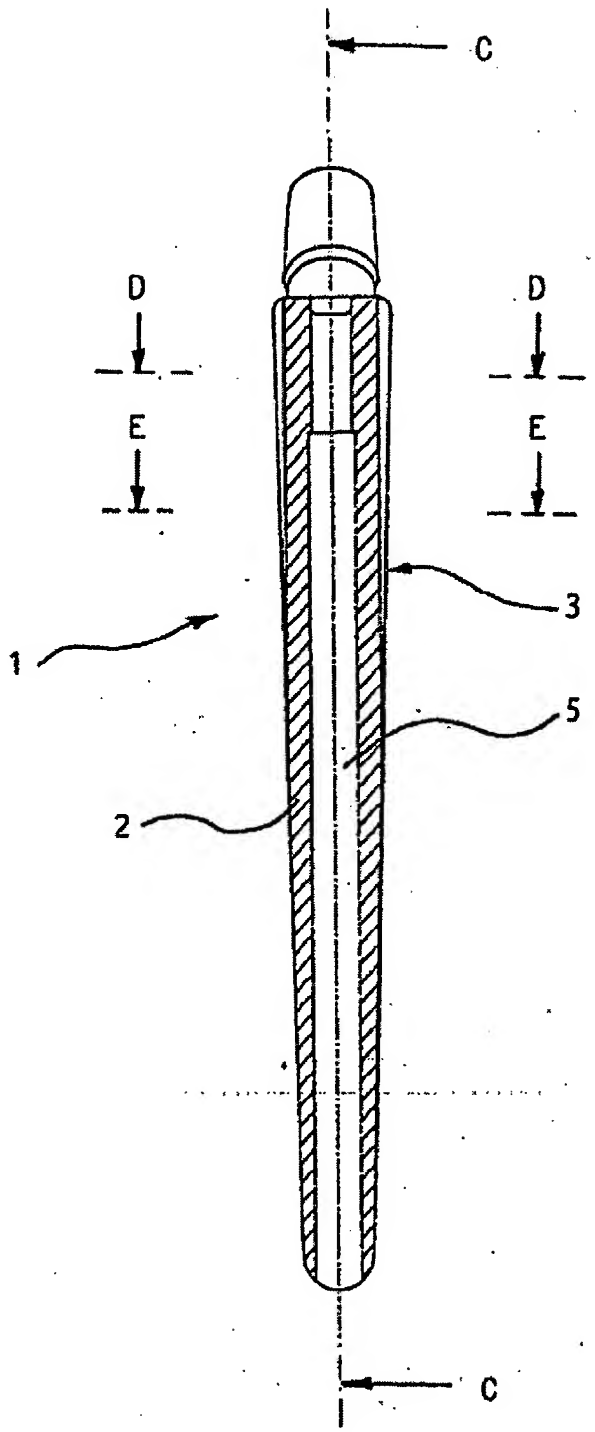

Fig. 1

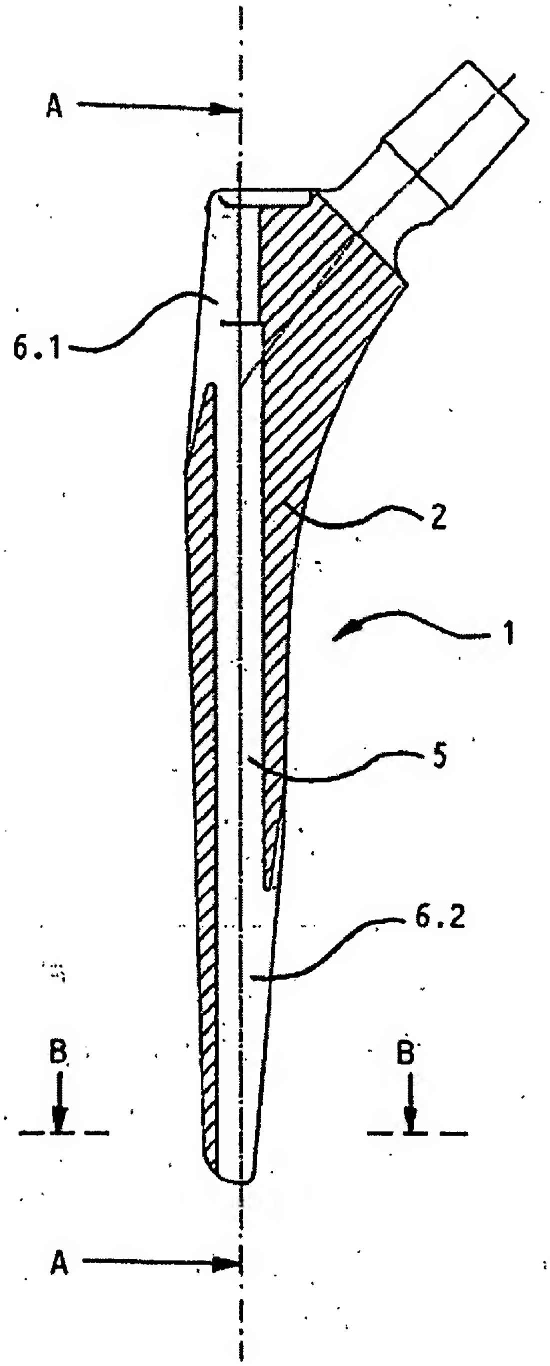

Fig. 2

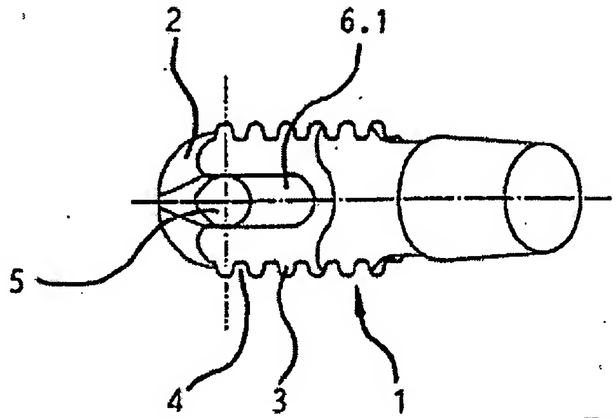

Fig. 3

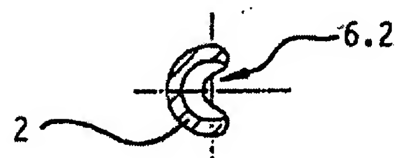

Fig. 4

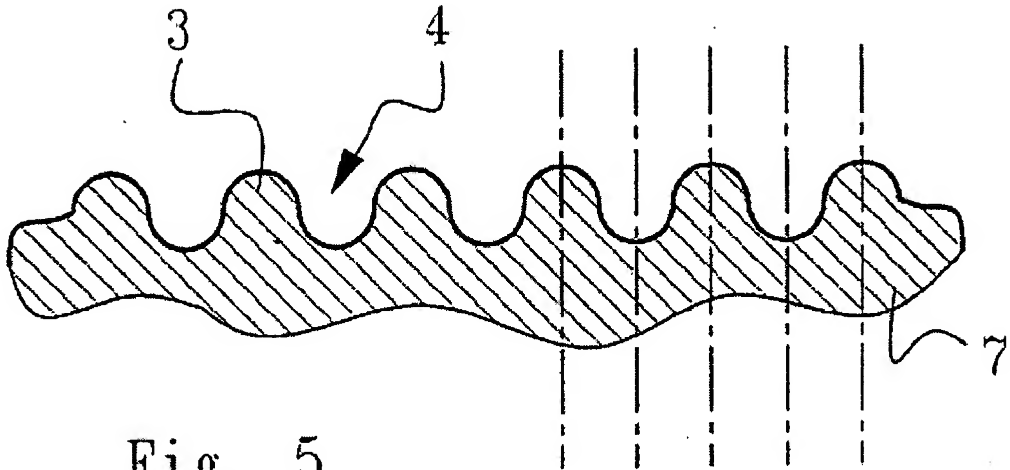

Fig. 5

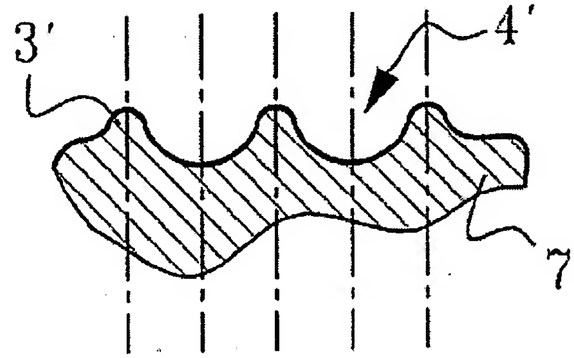

Fig. 5a

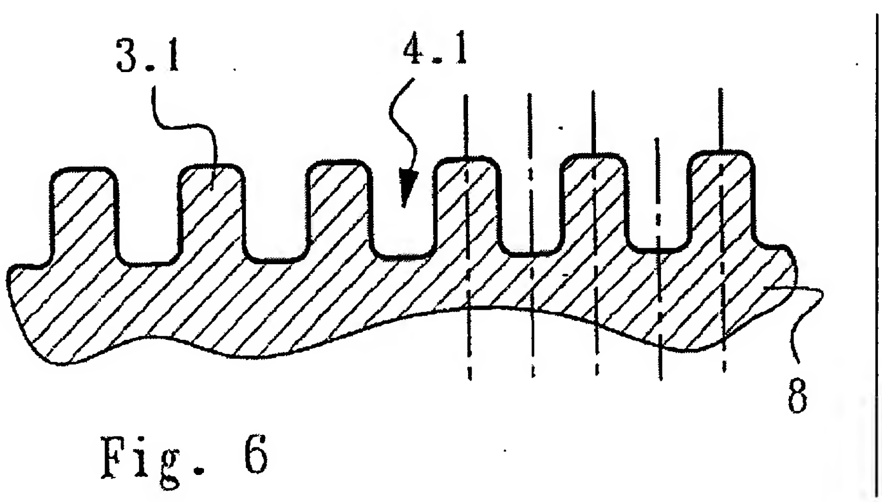

Fig. 6

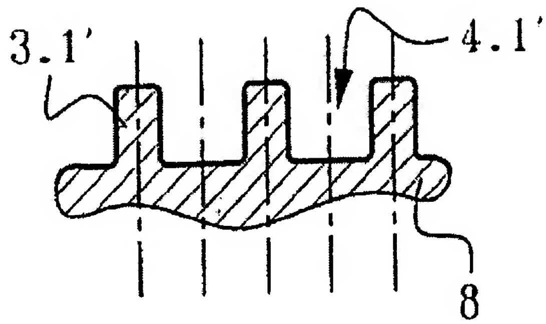

Fig. 6a

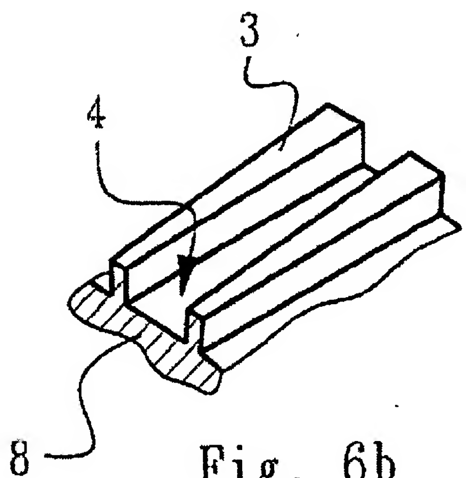

Fig. 6b

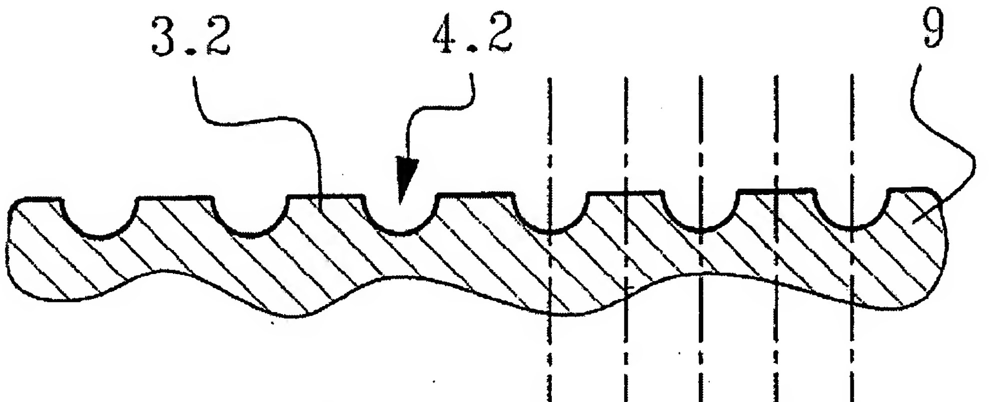

Fig. 7

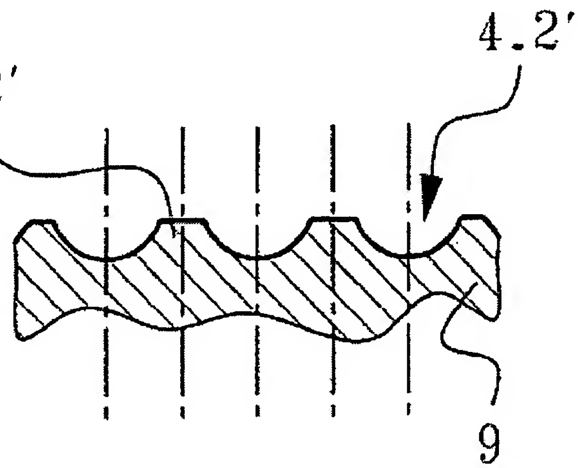

Fig. 7a

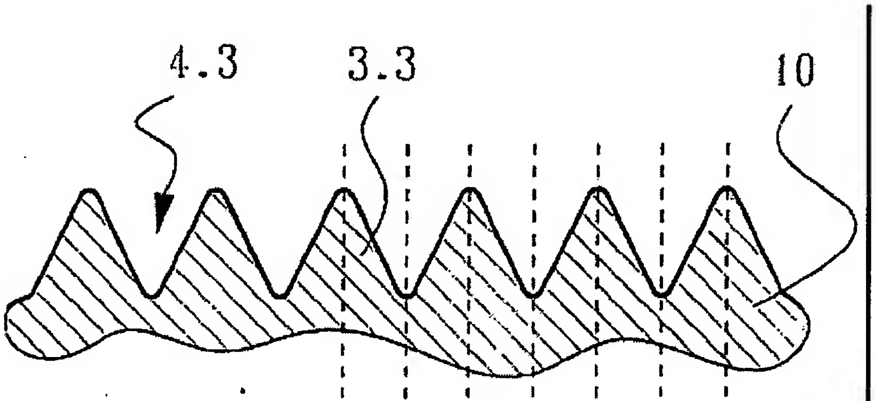

Fig. 8

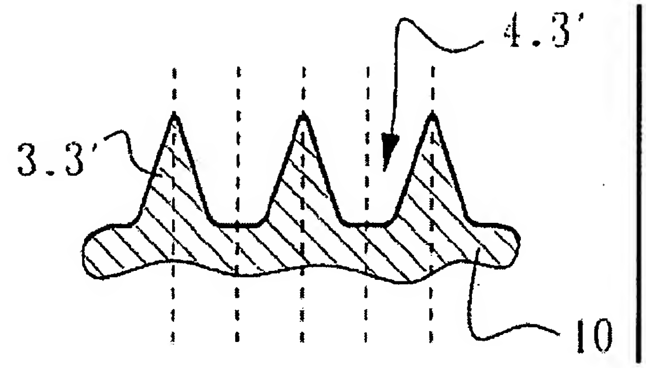

Fig. 8a

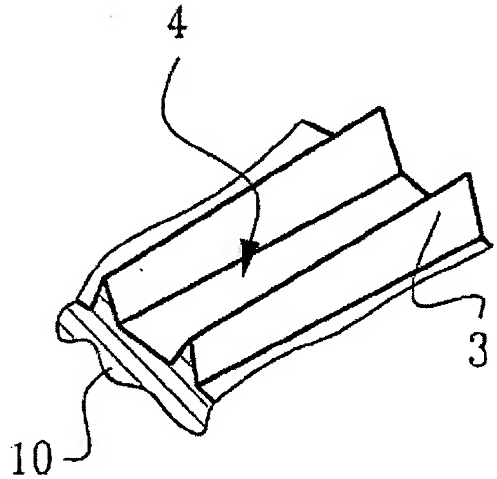

Fig. 8b

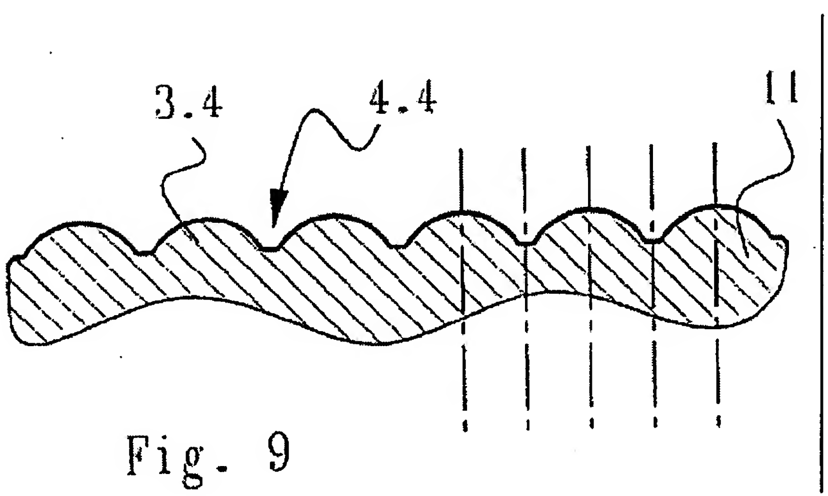

Fig. 9

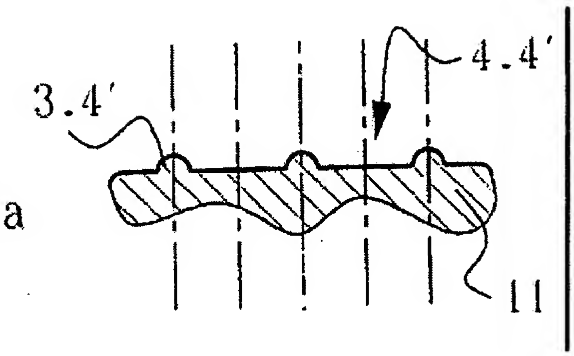

Fig. 9a

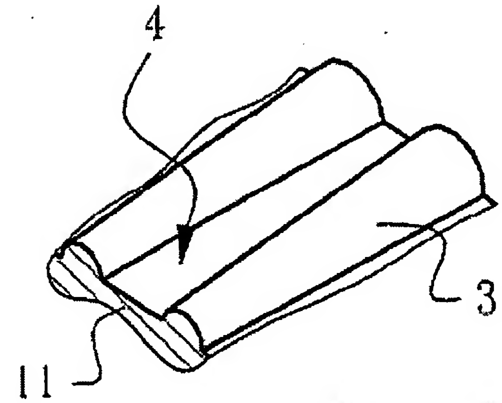

Fig. 9b

European
Patent Office
EUROPEAN SEARCH REPORT

Application Number
EP 95 25 0020

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl.^{6})
X Y	FR-A-2 602 672 (MARQUER) * page 3, line 10, to page 4, line 4; Claims 3, 7; Figures 1, 5 * ---	1-8 9-12	A 61 F2/36 A 61 F2/30
Y A	EP-A-0 098 224 (LORD) * Abstract; Claims 1-4; Figures 1-5 * ---	9 1-6	
Y	EP-A-0 550 117 (ARTOS MEDIZINISCHE PRODUKTE) * entire document * ---	10-12	
X	EP-A-0 222 236 (GEBRÜDER SULZER) * entire document * ---	1-6	
A	EP-A-0 141 022 (GEBRÜDER SULZER) * Abstract; Claims; Figures * ---	1-4, 6, 9	
D, A	DE-C-32 16 539 (WALDEMAR LINK) * entire document * ---	1, 2, 4-8	TECHNICAL FIELDS SEARCHED (Int. Cl.^{6})
A	EP-A-0 209 516 (VEREINIGTE EDELSTAHLWERKE) * Figure 2 * ---	1	A 61 F
P, X	DE-U-94 01 529 (ARTOS MEDIZINISCHE PRODUKTE) * entire document * ---	1-12	
A	EP-A-0 378 044 (GEBRÜDER SULZER) ---		

The present search report has been drawn up for all claims.

Place of search	Date of completion of the search	Examiner
THE HAGUE	June 13, 1995	Klein, C.

CATEGORY OF CITED DOCUMENTS

X: Particularly relevant if taken alone.
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T: Theory or principle underlying the invention.
E: Earlier patent document, but published on, or after the filing date.
D: Document cited in the application.
L: Document cited for other reasons.

&: Member of the same patent family, corresponding document.